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THREE TOOLS FOR MEASURING HEIGHT GROWTH IN FIELD PLANTINGS COMPARED

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ABSTRACT. — Three methods of measuring height growth in field plantings are compared.

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Three devices for measuring tree height growth were compared for accuracy: embossing tape, bamboo sticks, and a standard meter stick. The bamboo sticks were used in a prior study (Rudolph 1964), but the use of embossing tape has not been previously described in the literature.

METHODS AND MATERIALS

The study was done in a jack pine plantation near Rhinelander, Wisconsin. Heights were measured weekly for each method on 60 trees.

Before the growing season, we inserted a stainless steel pin into the terminal shoot of each tree 20 to 25 cm below the bud to serve as a reference mark for all three measurement methods. A second pin was inserted about 30 cm below the first pin as an undisturbed reference point to obtain a pre- and post-season measurement for total seasonal growth. This accumulated seasonal growth measurement served as a control. The three measuring devices were prepared and used as follows:

1. *Embossing tape.* — A strip of embossing tape about 90 cm long was attached to the base of a lateral branch 15 to 25 cm below the terminal bud by exposing a portion of the adhesive surface, wrapping it around the lateral branch, and adhering the two adhesive surfaces together (fig. 1). This joint was further secured by stapling. Where large amounts of growth occurred, more tape was added by sticking and stapling. Weekly growth was marked by stretching the tape taut in a vertical position parallel to the leader and punching a hole in the tape opposite the tip of the leader with a tool made from an ordinary laboratory forceps.

2. *Bamboo stick.* — A thin bamboo stick was taped to the main stem of each tree with 3M[1] bonded tape so that the stick extended well above the leader. A coping saw was used to mark the stick each week at the tip of the terminal bud.

3. *Meter stick.* — For the meter stick, measurements were taken each week from the reference pin to the tip of the terminal bud and recorded.

The authors took turns recording weekly measurements to eliminate bias. Total time for set-up, field measurements, and raw data work up to summary stage was 1,022 minutes for the meter stick, 938 minutes for the bamboo sticks, and 742 minutes for the embossing tape.

[1] *Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

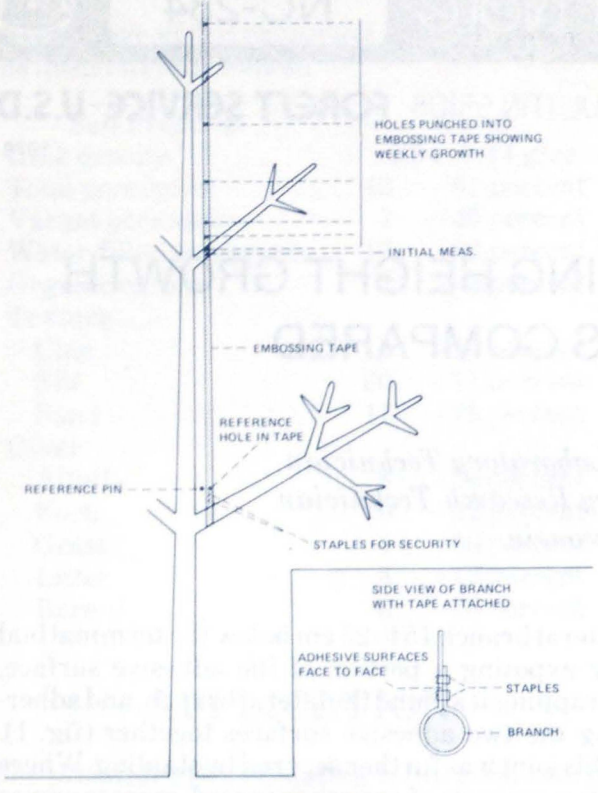

Figure 1. — *Schematic diagram showing use of embossing tape to obtain growth measurements.*

RESULTS AND DISCUSSION

Weekly growth. — In comparing mean weekly growth for all 60 trees by correlation coefficients and paired "t" tests, the meter stick method served as the control against which the other methods were tested. The growth data showed that the three methods were highly correlated (0.999), for both the bamboo stick and embossing tape when compared with the meter stick method. The paired "t" test showed no significant differences between methods. Hence, any of the three methods is technically acceptable and the choice of method should be based on time or cost.

Seasonal growth. — In comparing total seasonal growth, the pre- and post-seasonal measurements for total growth using the undisturbed pin served as the control. These data showed a high correlation with all three methods (table 1). The paired "t" test, however, showed the meter stick method as the only one not significantly different from the control at the 0.05 percent level. A coefficient of variation of overall means of all methods was approximately the same.

Table 1. — *Accuracy of measurements using the three tools*

Tool	Mean total height for all trees	"t" value	Coefficient of variation of x
	mm		*percent*
Meter stick	492.8	2.067	9.23
Bamboo stick	499.0	[1]3.912	9.38
Embossing tape	499.5	[1]2.669	9.17
Control	494.9	--	9.44

[1]Significant at 0.05 percent level.

The meter stick underestimated the true value by about 0.05 percent, where as the bamboo stick and embossing tape overestimated the true values by 0.9 and 1.0 percent. The paired "t" test showed the meter stick method to be more precise, but this test is extremely sensitive to variation in paired observations and should not influence the decision on which method to use.

Stretching of the embossing tape could be partly responsible for the slightly larger error associated with this method. However, we feel this method has advantages such as saving in time and manpower, less damage to trees, and ease of application. Moreover, the tape can be pre-labeled with all identification, can easily be added to if large amounts of growth occur, and can easily be stored at collection time.

The bamboo stick method resulted in occasional loss of terminal shoots due to cuts from the saw, or by girdling with the tape or ribbon used to secure the stick to the tree. Breakage of the sticks from too deep a cut by the saw was yet another problem.

The bamboo stick and embossing tape methods also offer the advantage of requiring only one person to obtain the measurements.

Costs of materials were not compared but we feel the time and manpower saved by using the embossed tape method would compensate for any difference in cost of materials.

LITERATURE CITED

Rudolph, Thomas D. 1964. Lammas Growth and Prolepsis in Jack Pine in the Lake States. For. Sci. Monog. 1964 (6):43.

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